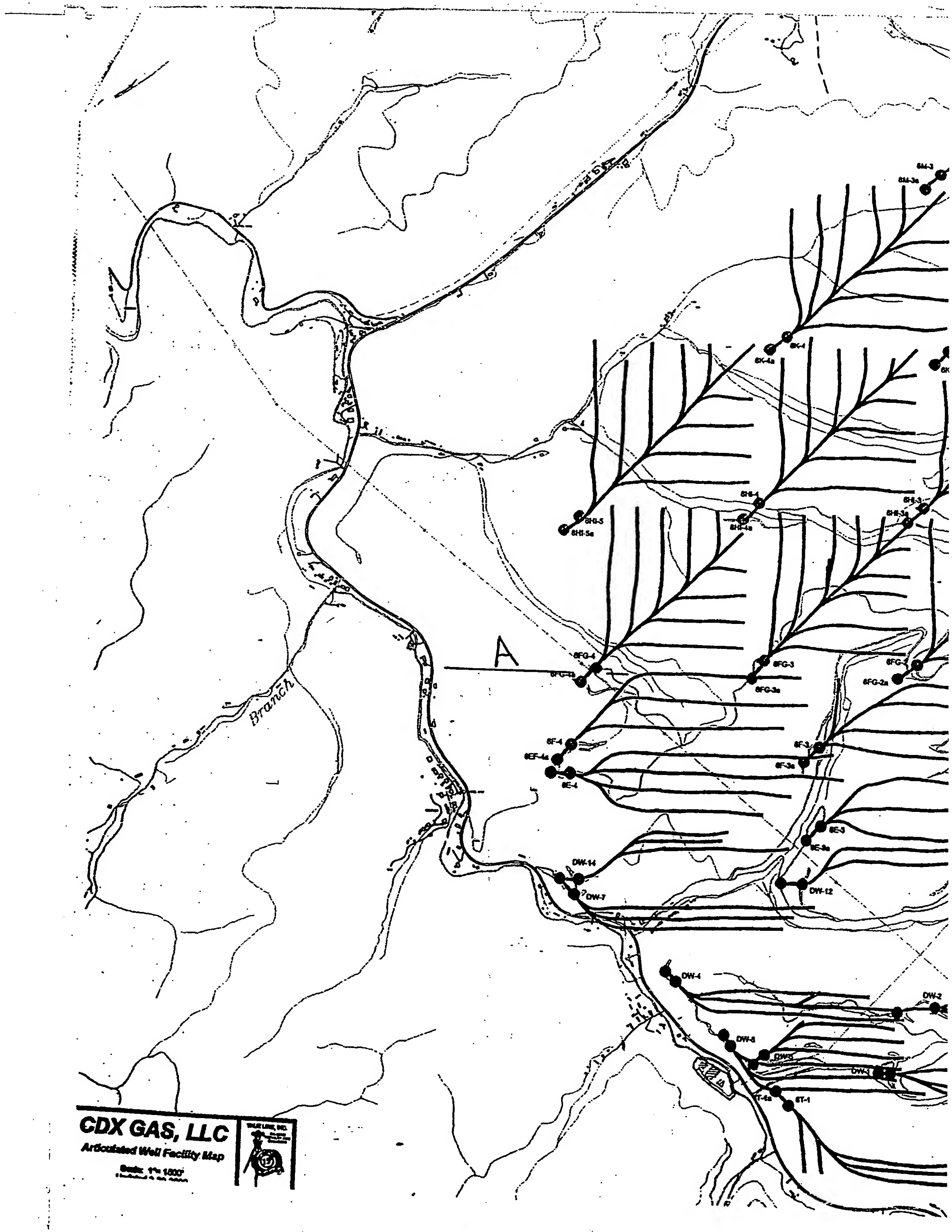
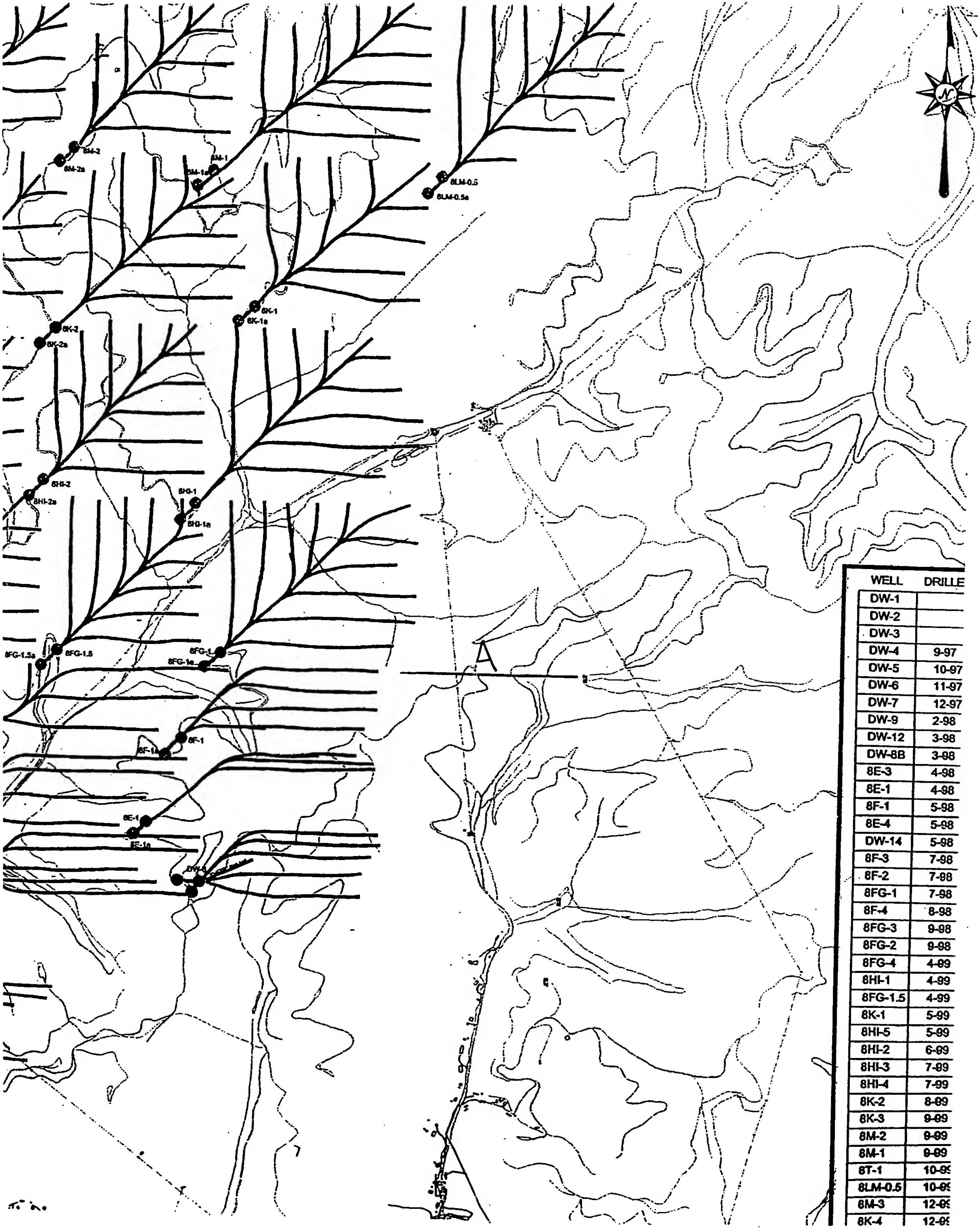


CDX GAS, LLC
Articulated Well Facility Map
A
Branch
8M-3
8M-3a
8K-4
8K-4a
8HI-5
8HI-5a
8HI-4
8HI-4a
8HI-3
8HI-3a
8FG-4
8FG-4a
8FG-3
8FG-3a
8FG-2
8FG-2a
8F-4
8EF-4a
8E-4
8F-3
8F-3a
8E-3
8E-3a
DW-14
DW-7
DW-12
DW-4
DW-2
DW-8
DW-5
DW-1
8T-1
8T-1a



WELL	DRILLE
DW-1	
DW-2	
DW-3	
DW-4	9-97
DW-5	10-97
DW-6	11-97
DW-7	12-97
DW-9	2-98
DW-12	3-98
DW-8B	3-98
8E-3	4-98
8E-1	4-98
8F-1	5-98
8E-4	5-98
DW-14	5-98
8F-3	7-98
8F-2	7-98
8FG-1	7-98
8F-4	8-98
8FG-3	9-98
8FG-2	9-98
8FG-4	4-99
8HI-1	4-99
8FG-1.5	4-99
8K-1	5-99
8HI-5	5-99
8HI-2	6-99
8HI-3	7-99
8HI-4	7-99
8K-2	8-99
8K-3	9-99
8M-2	9-99
8M-1	9-99
8T-1	10-99
8LM-0.5	10-99
8M-3	12-99
8K-4	12-99

JOURNAL OF PETROLEUM TECHNOLOGY

SEPTEMBER • 2001

Interview—2002 SPE President Stephen A. Holditch

Field Development

Horizontal Well Technology

Knowledge Management

Official Publication of the Society of Petroleum Engineers • www.spe.org

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Management

On the Cover

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September 2001 • Volume 53 Number 9

MANUSCRIPT SUBMISSIONS

Authors' instructions upon request. Send three double-spaced typed copies of manuscripts to Peer Review Coordinator, SPE Office in Dallas.

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BPA

Feasibility of Coalbed Methane Exploitation in China

Coalbed methane exploitation by use of a network of horizontal wells is a new technique. Several horizontal wells or horizontal wells with several branches are drilled to form a network, and coalbed methane is produced by pumping water out of the coalbed. This technique has been used successfully in West Virginia. Coalbed gas seepage in China's low-pressure and -permeability coal seams can be improved by use of horizontal networks.

Introduction

Coalbed methane has been produced by use of vertical wells in the north, northeast, and south of China since 1990. More than 140 wells have been drilled and significant progress has been made with some wells producing as much as 4000 m^3/d. A large-scale methane gas field with commercial potential and direct economic benefit has not been found. New techniques suited to the geological conditions of coalbed methane in China must be found.

Horizontal Network Exploitation

In horizontal-well network exploitation of coalbed methane, several horizontal wells are drilled to form a network. Horizontal wells can be drilled to form a grid, or multiple-branched horizontal wells can be drilled parallel to each other. Grid-type networks are used in coal formations with a nearly constant thickness and gentle slope. Multiple-branched horizontal networks are used in coal formations with larger angles. Horizontal-well network exploitation is similar to coalbed methane exploitation by use of vertical wells where methane is desorped from the coal surface by removing water to reduce formation pressure and permit methane to flow into the wellbore by diffusion and seepage. The velocity of diffusion and seepage of coalbed methane in a horizontal-well network is faster than in a vertical well.

The diffusion velocity of coalbed gas is directly proportional to the diffusion coefficient and concentration gradient, and the diffusion coefficient is constant for a given coal seam. A horizontal well network can lower formation pressure and provide a large channel for seepage. Seepage velocity is directly proportional to pressure gradient and gas permeability and inversely proportional to gas viscosity. Because viscosity for coalbed methane is a constant and permeability is constant for a given coal seam, more coalbed gas can be produced by increasing the pressure difference.

Exploitation

Exploitation Example. In West Virginia, coal seams are at approximately 1000 m. Seam 4 has a 1.22-m average thickness, 8.5-m^3/t average gas content, and 3×10^{-3} to 4×10^{-3}-μm^2 permeability. Seam 6 is approximately 2 m thick and has a gas content that ranges from 12.74 to 15.57 m^3/t. Initially, water production per well from coal Seam 4 was 85 to 100 t/d but decreased to 15 to 30 t/d after 1 month of exploitation. Average gas production per well was 28 000 m^3/d. One or two wells are drilled per 110 acre block. Cumulative gas production from Seam 4 was 47.1×10^6 m^3 for 2 years of production and from Seam 6 was 1.42×10^7 m^3 for 3 years of production.

Feasibility. In general, coalbeds in China have undergone multiple uplifts, folding, and faulting. There are some coal areas with well-developed fissure systems and permeabilities between 1×10^{-3} and 10×10^{-3}-μm^2. Exploitation by use of horizontal well networks is feasible in areas such as Hedong in the east fringe of the Ordos basin, Qinshui basin, Shanxi province, and Liaoning province. Reservoir pressure can be reduced, allowing a large amount of coalbed methane to be desorped, diffused, and seeped in the area of anthracite and high gas content in the Qinshui basin. Coalbed methane exploitation will not succeed in areas with little water and where the coal is broken into granulitic and mylonitic coal. Areas should be evaluated and blocks selected that have a high gas content and well-developed coal fissures so exploitation will be successful.

Well Construction. Several horizontal wells can form a grid or a "twig-like" system can be formed with a main horizontal well with several branches. The well should be cased and cemented to the top of the coal seam before the coal seam is drilled. While drilling horizontal wells, the sidewall must be stabilized without the coalbed methane being totally desorped. Drilling fluids, cement, and fracture fluids must be carefully selected to prevent coal reservoir contamination. Underbalanced drilling with air or foam can be used to protect the coal reservoir.

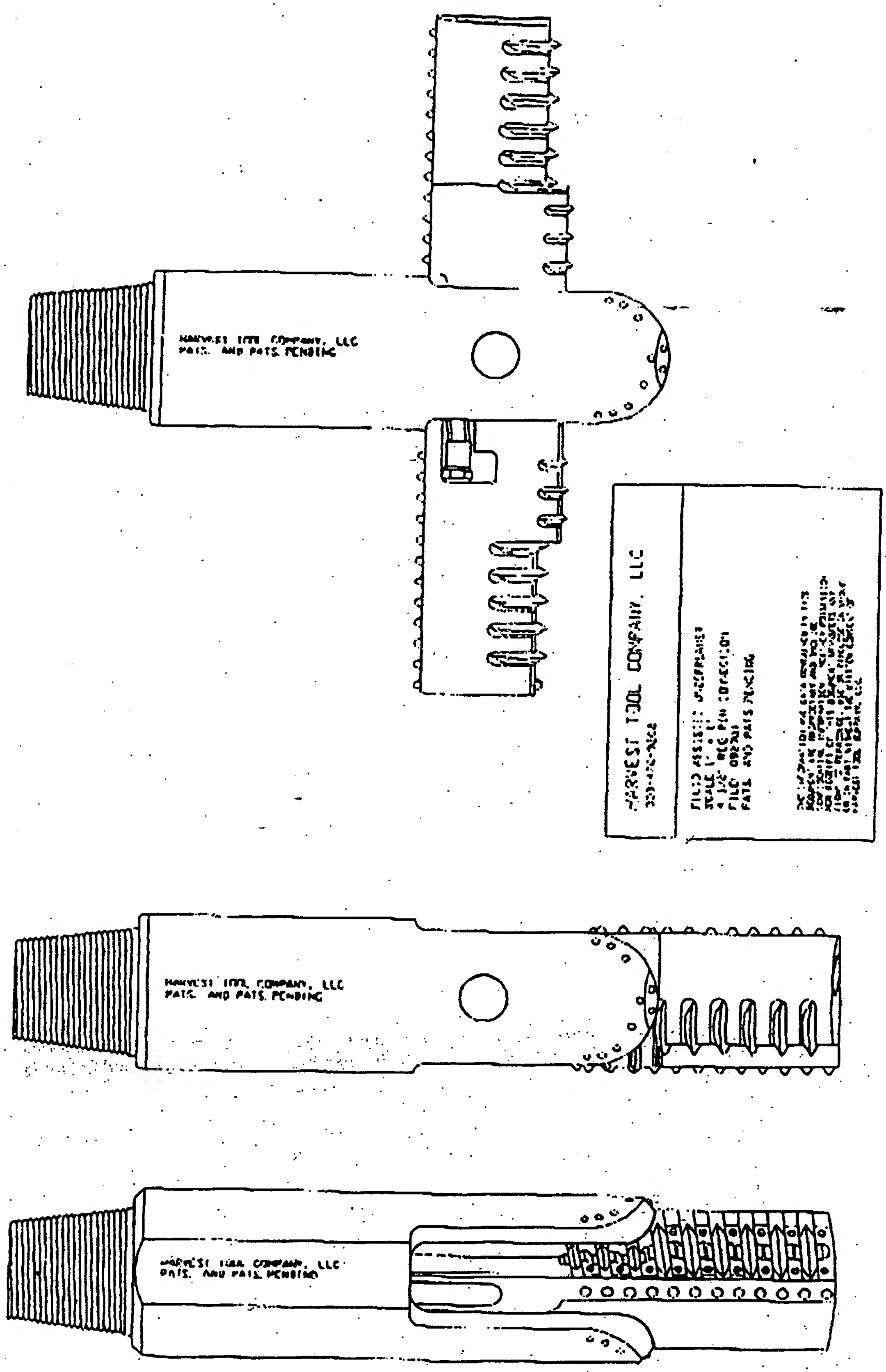
Long slotted liners can be used to increase water discharge. Pump plugging with coal grains or powder while pumping water can be prevented by use of a long sieve tube completion. Coal formations with low permeabilities can be fractured in the horizontal section, or a vertical well can be drilled at the end of a horizontal well or in the center of a grid and fractured.

Conclusions

1. Exploitation of coalbed methane by use of a horizontal network is a new technique that is feasible for use in China.
2. Horizontal networks are suitable for exploitation of coalbed methane in low-permeability and -pressure formations. **JPT**

This article is a synopsis of paper SPE 64709, "A Feasible Discussion on Exploitation Coalbed Methane Through Horizontal Network Drilling in China," by ***Weiguo Chi****, North China Bureau of Petroleum, Sinopec, and* ***Luwu Yang****, China United Coalbed Methane Corp. Ltd., originally presented at the 2000 SPE International Oil and Gas Conference and Exhibition in China, Beijing, 7–10 November.*

Please read the full-length paper for additional detail, illustrations, and references. The paper from which the synopsis has been taken has not been peer reviewed.



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Natural Gas Marketing

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LAGCOE SUPPLEMENT

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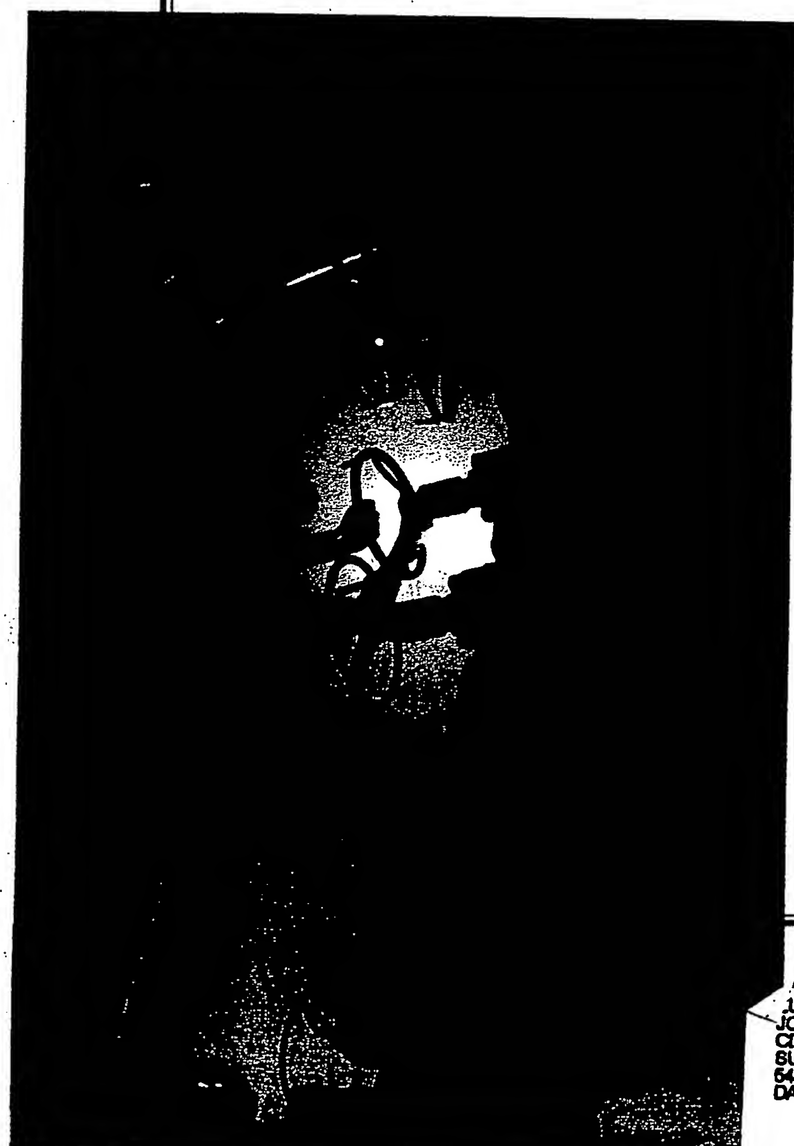

Brian Hall
President IOGA NY
"Across New York state new players are entering the action, bringing national attention to the Trenton-Black River."
Page 100

Mark Monroe
President OIPA
"Some tax provisions in the energy bill will help independents do more with their money. Some people say they are benefits. I would characterize them as removing detriments."
Page 106

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JOE ZUPANICK
CDX GAS
SUITE 280
5485 BELT LINE ROAD
DALLAS TX 75254-7687

Advances Key For Coalbed Methane

By Gopal Ramaswamy

BOMBAY, INDIA–The industry is now going though the second stage of the learning curve for producing coalbed methane. There are several key areas of learning, and emerging developments in these areas will help cut costs and enable "coal gas" to remain competitive in the U.S. and regional international gas markets throughout this decade.

The first stage of the coalbed methane learning curve, encompassing technology development and drilling and production activity through 2000, was characterized by:

- Extending coalbed methane drilling to low-rank coals (including regions now very familiar to North American operators such as the Powder River Basin in Wyoming, but also numerous other areas around the world such as the Cambay Basin in India);
- Refining coal seam gas content measurements;
- Developing simulation software for coalbed methane reservoir engineering and hydro-fracturing coal seams;
- Perfecting the cavitation, or "dynamic open-hole," completion method;
- Implementing effective produced water management practices under different field environments and regulatory requirements; and
- Developing field automation and information systems using Internet and supervisory control and data acquisition (SCADA) technologies.

One major effort in the second stage of the learning curve is enhancing coalbed methane production and recovery by injecting nitrogen or carbon dioxide directly into the coal seams. This technique is now passing through the pilot stage, and when commercially employed, it could rejuvenate some existing coalbed methane fields and generate higher gas outputs in several new fields.

Another emerging technique with significant potential is using microbes to enhance the natural process of secondary biogenic gas generation in coalbeds. By introducing anaerobic bacterial agents into coalbeds, microbially enhanced methane could be obtained from coalbeds that otherwise have only small production potential. There are, of course, some practical limitations imposed by coal surface area and biogasification reaction rates, but according to one researcher, if only 1/100 of 1 percent of existing U.S. coal reserves were converted into methane using this technique, recoverable gas would be increased by 23 trillion cubic feet!

Second Stage Focus

Looking more broadly, the second stage of learning is focused on:

- Extending the development regime to very high-rank coals such as anthracites previously not considered suitable for coalbed methane production;
- Applying directional and horizontal drilling as an alternate means to achieve tight well spacing (40-80 acres);
- Drawing produced water out of coal seams even while directional drilling from a single pad;
- Devising cheaper and more effective stimulation techniques than hydrofracturing; and
- Optimizing field facility sizing to produce at very low wellhead pressures.

Technology advancements in all of these areas should reduce project costs and enable coalbed methane to remain competitive, and help open new areas of development even without the Section 29 tax credits that originally spurred coalbed methane development in the late 1980s and early 1990s.

Anthracite coals have never been considered viable for coalbed methane development because of their low levels of permeability, but that may not be the case for all anthracites. For instance, in the United Kingdom, the South Wales anthracites are affected by tectonically developed fracture systems formed during Late Carboniferous Varisican compressional deformation. University of Wales scientists have shown that regions of deformed anthracites are, in fact, worthy of coalbed methane exploration.

There is a relationship between the rate of methane desorbed and the deformation intensity. In fact, the Welsh scientists believe that permeability would be enhanced and large gas reservoirs would be preserved if deformed coals were continuous. Multi-oriented cleats and fractures are expected in such deformed anthracites, which implies that regardless of the present in-situ stress conditions at depth, many permeability pathways will remain open, allowing gas migration. There would be some problems in producing water and methane because of the particulate coals, however.

Anthracite coals in many parts of the world could be potentially significant producers of coalbed methane. Gas contents in anthracites typically range from 700 to 1,500 cubic feet per ton, generally more than adequate for commercial development. In fact, commercial quantities of coalbed methane have already been produced from anthracite reservoirs in China.

Directional Drilling

Coalbed methane development usually requires dense drilling with 40- to 80-acre well spacing. Most conventional natural gas drilling is done on wider well spacing, usually on the order of 640-acre spacing. If typically takes eight to 10 coalbed methane wells to produce the amounts of gas that one good natural gas well can produce. Despite horizontal drilling's limited application in coal seams in the past, new developments in directional and multilateral drilling technology appear to be providing a means by which operators can drill multiple coalbed methane wells from a single pad and dewater the coals while drilling.

One new proprietary drilling technology from CDX Gas of Dallas, for example, is described by the company as "a new horizontal drilling system capable of placing up to 100,000 feet of drain hole beneath 1,000 acres from a single well site." CDX Gas says the system can recover more than 80 percent of in-place gas reserves within 36 months from one well, without dewatering delays.

The application for the patent on the new system, which CDX calls Z Pinnate™, states that the technology provides "an articulated well with a drainage pattern that intersects a horizontal cavity well. The drainage patterns provide access to a large subterranean area from the surface, while the vertical cavity well allows entrained water, hydrocarbons, and other deposits to be efficiently removed and/or produced."

Although performance data on the use of the technology are not yet available, the technology is reportedly being applied to degas coals before mining in West Virginia and the Arkoma Basin. Its potential in coalbed methane drilling will become more evident once its applicability to coal degasification is determined. If successful, this type of technology could represent the future of directional drilling in coalbed methane,

changing the way coalbed methane drilling and production are carried out.

Multilateral technology is proving highly effective in operations such as those designed to extract heavy oil from shallow reservoirs in eastern Venezuela, where large subsurface coverage has been obtained by multilateral drilling. The technique has been used in West Virginia to drill coalbed methane wells that produce nearly 1 million cubic feet per day. Referencing the successful application in West Virginia, Chinese researchers have determined that a similar "horizontal network drilling" approach is applicable to low-pressure, low-permeability coalbed methane reservoirs in China.

Stimulation Techniques

As a rule, coalbed methane wells are stimulated by hydro-fracturing the coals. However, hydro-fracturing is a costly technique, and developing a less expensive stimulation method that is equally–or even more–effective would greatly reduce total well costs.

One potential alternative technique is cavity-induced stimulation. As a coalbed methane pioneer, Amoco (now merged with BP) demonstrated in the early 1990s that the cavity completion process can also be carried out in cased holes where hydro-fracturing was initially used to stimulate the formation. The process enlarges the collapse and failure zones behind the casing, thereby accelerating gas production. Using foamed water cleanouts further increased gas production rates.

Arco (since acquired by BP) subsequently improved the technique by developing a patented cavity-induced stimulation process that uses foam. This process is applicable to new and old wells alike, both cased and hydro-fractured. Injecting high pressure gas into the coal seam, and then suddenly releasing the pressure, causes the disintegration of coal surrounding the bore hole and makes connections to the fractures and cleats.

Although much work remains to be done, with continued application and refinement by the industry, cavity-induced stimulation could ultimately become a preferred method for stimulating coalbed methane wells, replacing the more expensive hydro-fracturing technique while yielding greater gas production rates.

A promising alternative is the PGDBK well stimulation technique. PGDBK is the Russian acronym for caseless, charge-powdered pressure generators. Although relatively new to coalbed methane, this stimulation technique has a 30-year history, with applications in more than 30,000 oil wells in the Eastern Hemisphere. The method has also been successfully used in oil wells in the Powder River Basin as well as other U.S. basins. Through a combined effect of mechanical, thermal and chemical actions, the PGDBK technique increases pressure communication between the extended reservoir and the well bore to increase oil and gas production. It has also had exceptional success in stimulating injection wells.

Geotec Thermal Generators Inc. in Boca Raton, Fl., is the licensee for the PGDBK method in the North, South and Central America. Geotec Thermal Generators Inc. is the licensee for the PGDBK method in the United States. The company says that part of its strategy is to use the technology to commercially produce the vast coalbed methane resources in the Rocky Mountain region. PGDBK is not an explosive fracturing method; the tensile strength of the formation rock is overcome to create the fractures. However, the rock yield strength is never reached. The technology works best in hard formations with brittle attributes, such as limestones, tight consolidated sandstones, shaly formations, etc. Rather than crushing the coalbed seams, PGDBK creates multiple fractures that link (transverse) natural fractures in coal seams and enables better communication between matrix systems, existing fractures and the created fractures. The result eliminates not only skin effect and well bore damage, but enhances fracture conductivity, improves productivity of wells, and increases hydrocarbon recovery.

PGDBK fracture treatment is tailored-designed for each well. This helps to control the number of fractures to be created, their lengths, and orientation. This is important when dealing with reservoirs with close water contacts and also thin seals.

Optimizing Field Facilities

The final focal point in the second stage of coalbed methane learning relates to field facilities optimization. Much of this is dependent on the specific field under development, although virtually all coalbed methane projects share certain common aspects with respect to production facilities. One is moisture removal. Water content is highest in younger coals, such as those found in the Powder River Basin. The mechanical separators used in most applications today are typically not highly efficient at removing moisture from the coals. A new design is needed for wellhead separators so that pipeline condensation is eliminated. Pressure regulation is also a concern. An economical, low-pressure, high-flow, low-headloss pressure regulator would have considerable value in coalbed methane operations.

Above all, more work is needed to help operators determine how to optimize field facility design. One consideration, for example, is deciding whether to keep wellhead pressure at 5 psi or less at the early stage of development to deliver methane to central compression, or use other forms such as satellite compression. Another consideration is determining whether to build a small, captive gas-fired generating plant to power field production and gas compression equipment or draw power from overhead utility lines (sometimes requiring lines top be run to well sites in remote areas).

Of course, if directional drilling technologies gain widespread acceptance in coalbed methane development, field facilities would be very different from what has been used so far to produce vertical wells. Unlike many conventional natural gas wells, coalbed methane wells cannot be shut in (shutting wells in reduces permeability). This is an apparently insurmountable problem, but some investigation needs to be done if only for the advantage that temporarily shutting in wells can give to operators for market-determined production. ☐

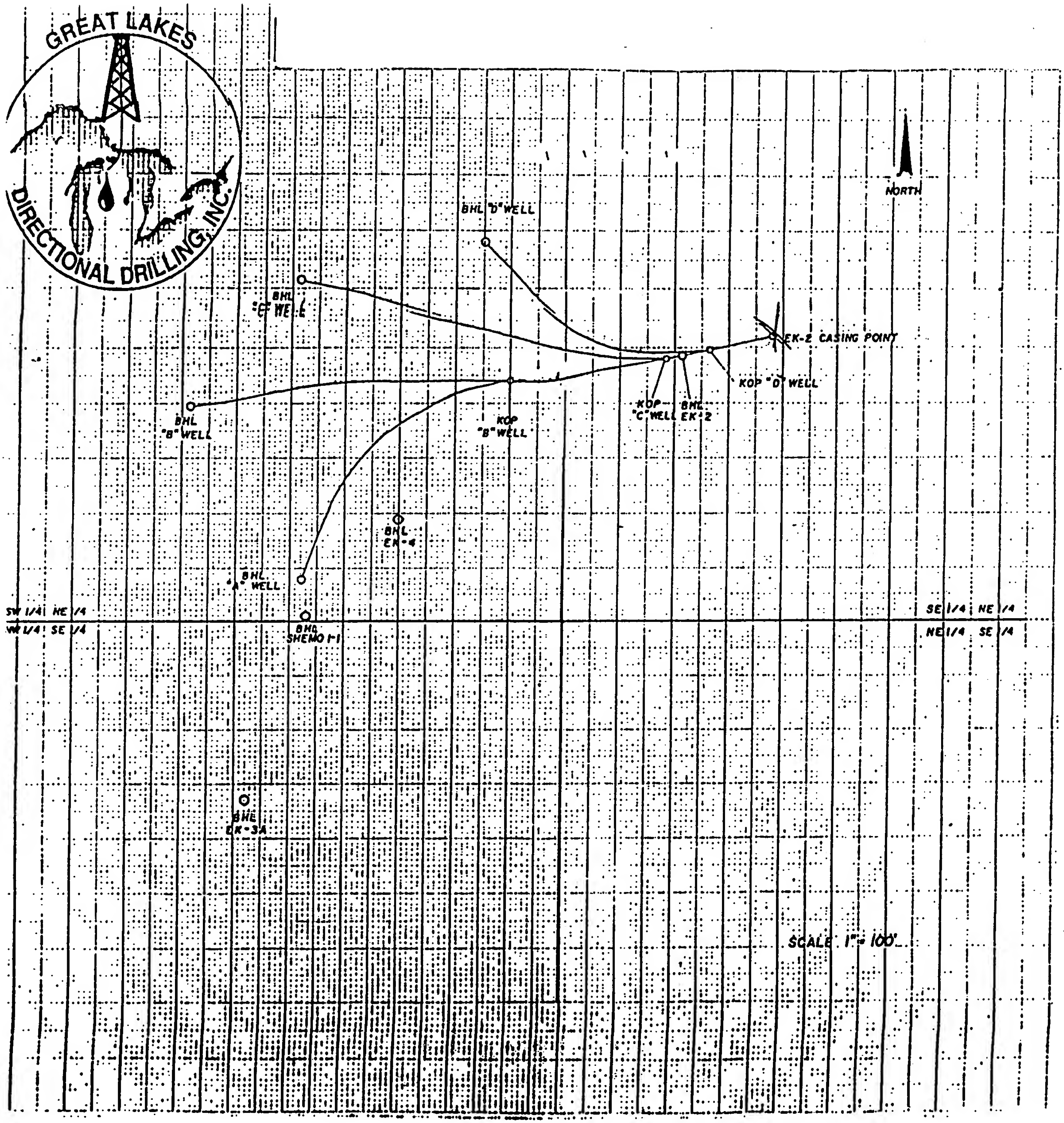
Editor's Note: The author acknowledges Dr. Anil Chopra of Petrotel in Dallas for suggestions that have been incorporated in this article. For additional information on the PGDBK method, visit Geotec Thermal Generators Inc.'s Web site at www.geo-tec.net.

GOPAL RAMASWAMY

Gopal Ramaswamy is managing director of Reliance Gas (P) Ltd., a member of the Reliance Industries Group, which is active in the oil and gas upstream and downstream industries in India. He is also adviser to Reliance Industries. Ramaswamy previously served as a geophysicist with an Exxon Mobil subsidiary in India, consultant to Petrobras, adviser to India's Ministry of Petroleum & Chemicals, and was a member (offshore) of the government's Oil & Natural Gas Commission in charge of discoveries and development of Bombay High oil and gas fields. In the early 1990s, he was the senior author of the first coalbed methane studies in India, focused on the Cambay Basin and eastern coal basins. Ramaswamy holds a Ph.D. in physics.

Drilled Aug 1994

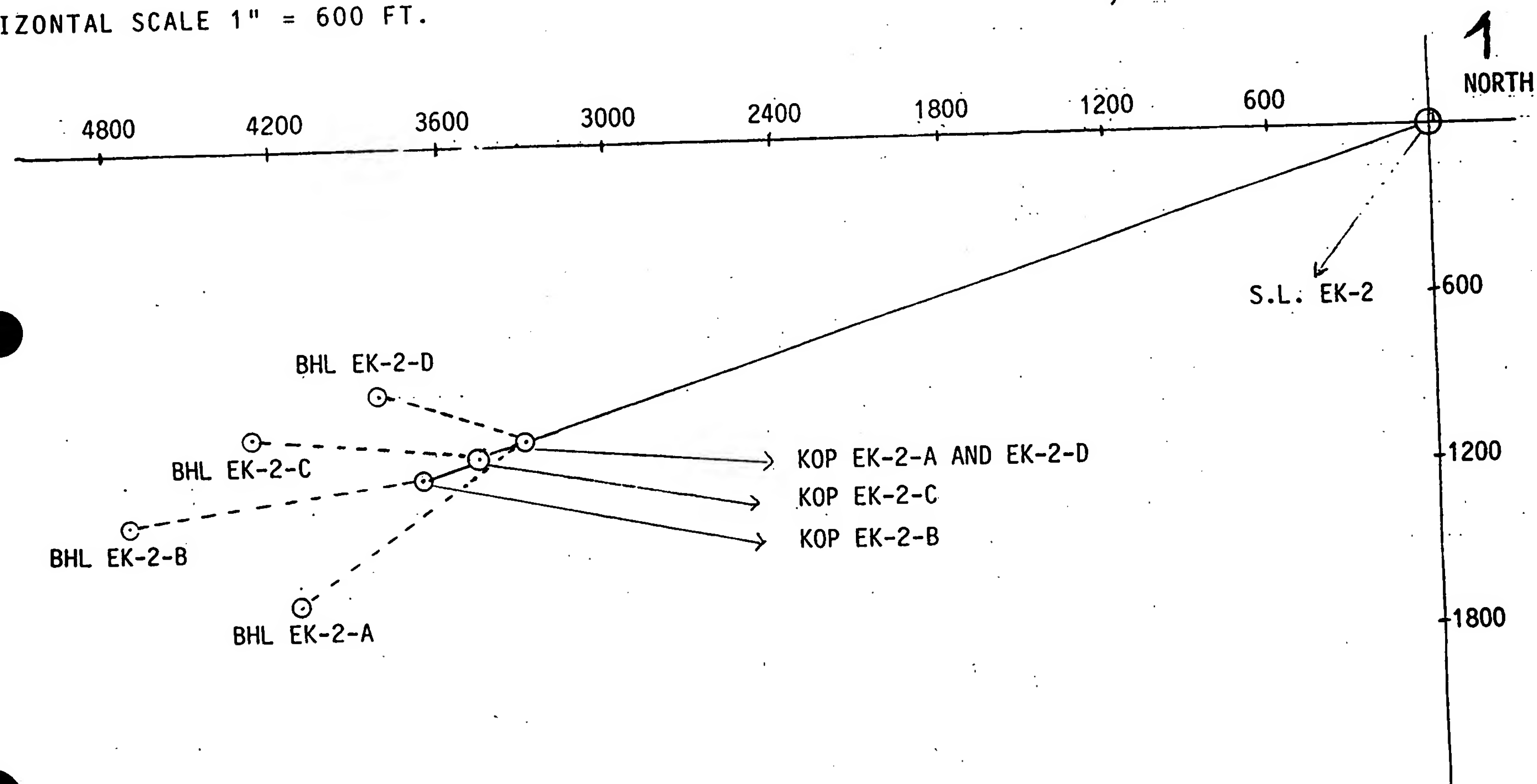
Actual



ANR STORAGE COMPANY
EXCELSIOR 6 -- E. KALKASKA 1
GAS STORAGE FIELD
PLAN VIEW COMPOSITE PROJECTION

PROPOSED

HORIZONTAL SCALE 1" = 600 FT.

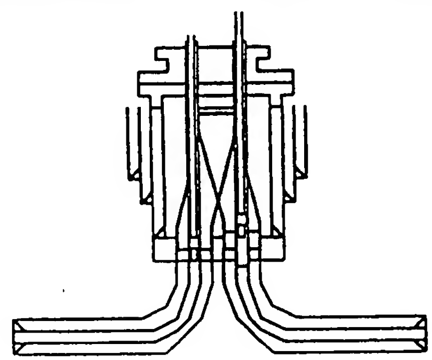


USED By Maurer Eng: Bob Knoll presentation & Petroleum Tech Transfer Council

Marathon Baker Splitter System

Install Side by Side Wellheads

Great Economics One Slot = Two Wells



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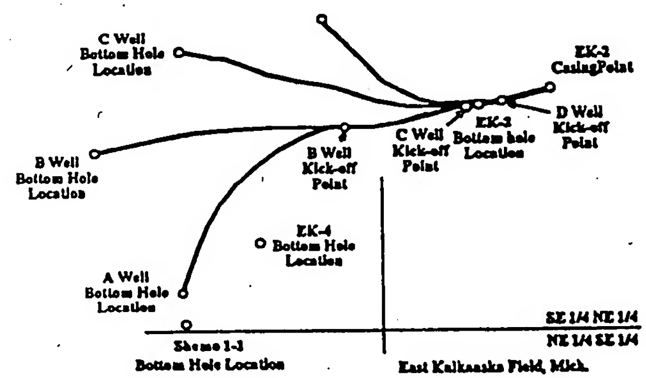
Example of Lateral Extensions



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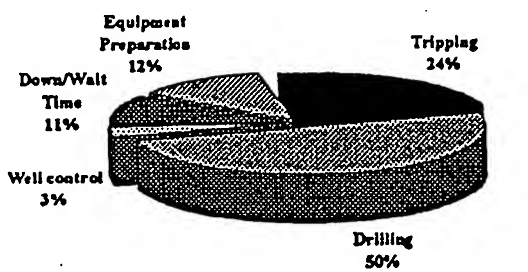
East Kalkaska 1-2 Time Analysis high drill time ratio



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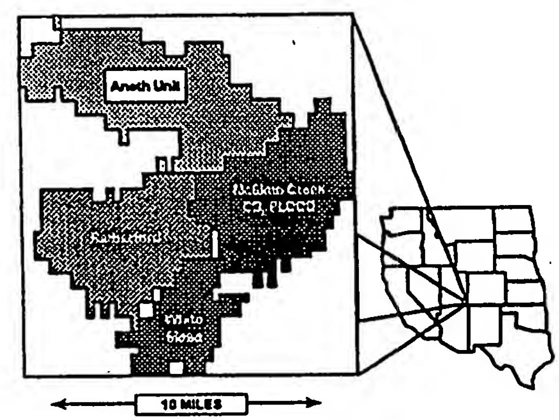
ANETH FIELD, S.E. UTAH



Daily Report -- GENERAL CHEMIC[redacted] CANADA LTD.
Well Name: BRINE WELL P-7 TO P-4 #2
Field: ANDERDON TWP.
Rig: BRADCO RIG #2
Last Csg. Pt: 1050'
Size: 8 5/8"
Co. Rep: KATHY McCONNELL
Tool Pusher: SAM STEVENSON
Phone:

Date: 07-[redacted]1998
Report No: 30
Job No:
Rept. Ending: 6:00A.M. 07-24
End Depth: 1747'
Start Depth: 1150'
Daily Cost: $8,000.00
Total Cost: $30,400.00
Fax:

Job Parameters:

Plane of Proposal:	S88.5W			
Surface Location	N/S:	0.00	E/W:	0.00
Bottom Hole	N/S:	4.65	E/W:	600.00
Mag. Corr. True:	0.00		Grid:	0.00
Kelly Elevation:	10.00			

Time and Activity Breakdown:

8:00 A.M.	P.U. MOTOR #350001 G.L. SET ON 2.12º, SURFACE TEST & T/IN.
10:30 A.M.	R.U. W.C..
11:30 A.M.	DRLG. W/116 STKS. 850 PSI., 800 TO 1,000 PSI. HYD. TQ.
12:00 MidNight	07-24-98
4:00 A.M.	HIT CAVERN @ 1747' MD, 1144' TVD, 642' V.S., SHOULD HAVE BEEN 550' V.S.?? 12 HRS. DRLG., 597', AVG. 50' PER HR.
4:30 A.M.	PULL BACK 3 JTS. & GOING TO CIRC. TILL NOON W/ F.W..

NOTE the DATE!

SECTION 4.0 - CASING AND CEMENTING SUMMARY

Surface Casing:

Csg. Size OD (mm)	Hole Size (mm)	Weight (kg/m)	Grade & Thread	Depth (mKB)	Cementing
298	381	69.94	K-55 ST&C	30.5 m	3.4 tonnes Class G cement + 2% $CaCl_2$ - cmt to surface with 100% excess

Intermediate Casing:

Csg. Size OD (mm)	Hole Size (mm)	Weight (kg/m)	Grade & Thread	Depth (mKB)	Cementing
219	273	35.72	K-55 ST&C	307	Fill Cement - 10.5 tonnes Class G cement + 2% $CaCl_2$ + 8% gel - cmt to surface with 100% excess Tail Cement - Class G cement + 2% $CaCl_2$ - cmt volume will be calc to push fill cmt to surface

Well bore intersect!

Horizontal Hole:

200 mm horizontal hole will be drilled in two directions to intersect with wells P-4 and P-10 (see plan view and cross-sectional view of horizontal portion of the well)

Production Casing:

Csg. Size OD (mm)	Hole Size (mm)	Weight (kg/m)	Grade & Thread	Depth (mKB)	Cementing
140	200	20.83	K-55 ST&C	370	hung in well head

GENERAL CHEMICAL CANADA L
BRINE WELL #R-10 TO #R-5
ANDERDON TWP., ESSEX CO., MI

GREAT LAKES DIRECTIONAL DRILLING

Report of Survey

Minimum Curvature Method

MEASURED DEPTH	INCL.	DIRECTION	VERTICAL DEPTH	VERTICAL SECTION	RECTANGULAR COORDINATES		DLS Deg/100'
1130.00	0 54	N 9 0 E	1126.88	-1.30	9.18 N	1.54 E	
1161.00	24 24	N 73 0 W	1156.94	4.94	11.32 N	4.64 W	78.35
1187.00	58 48	N 73 0 W	1176.10	21.32	16.30 N	20.90 W	132.31
1203.00	76 18	N 88 0 W	1182.21	35.87	18.60 N	35.39 W	139.19
1213.00	82 0	S 83 0 W	1184.10	45.66	18.16 N	45.19 W	105.14
1225.00	90 6	S 73 0 W	1184.93	57.27	15.67 N	56.87 W	107.03
1235.00	94 30	S 71 54 W	1184.53	66.71	12.66 N	66.40 W	45.35
1245.00	96 0	S 72 24 W	1183.61	76.10	9.61 N	75.88 W	15.80
1256.00	93 24	S 75 48 W	1182.71	86.56	6.61 N	86.42 W	38.83
1266.00	92 54	S 78 54 W	1182.16	96.24	4.42 N	96.16 W	31.35
1276.00	93 54	S 83 6 W	1181.57	106.05	2.86 N	106.02 W	43.10
1286.00	94 36	S 86 18 W	1180.82	115.96	1.94 N	115.95 W	32.67
1296.00	93 12	N 90 0 W	1180.14	125.91	1.62 N	125.92 W	39.48
1306.00	90 30	N 87 48 W	1179.82	135.91	1.81 N	135.91 W	34.82
1315.00	87 36	N 85 12 W	1179.97	144.90	2.36 N	144.89 W	43.27
1325.00	86 0	N 83 24 W	1180.53	154.85	3.35 N	154.82 W	24.06
1335.00	84 30	N 80 36 W	1181.36	164.76	4.73 N	164.69 W	31.68
1346.00	85 18	N 79 18 W	1182.33	175.59	6.65 N	175.48 W	13.84
1356.00	86 42	N 77 36 W	1183.03	185.41	8.64 N	185.25 W	21.99
1366.00	87 30	N 75 42 W	1183.54	195.19	10.95 N	194.97 W	20.59
1376.00	87 54	N 77 12 W	1183.94	204.96	13.29 N	204.68 W	15.51
1386.00	88 24	N 78 54 W	1184.26	214.79	15.36 N	214.46 W	17.71
1396.00	88 48	N 81 0 W	1184.51	224.67	17.11 N	224.30 W	21.37
1405.00	89 12	N 83 0 W	1184.66	233.62	18.36 N	233.21 W	22.66
1415.00	90 0	N 84 42 W	1184.73	243.58	19.43 N	243.15 W	18.79
1425.00	90 30	N 86 0 W	1184.69	253.57	20.24 N	253.12 W	13.93
1435.00	90 24	N 85 42 W	1184.61	263.56	20.96 N	263.09 W	3.16
1445.00	90 6	N 87 30 W	1184.57	273.55	21.56 N	273.08 W	18.25
1455.00	89 42	N 89 0 W	1184.59	283.55	21.86 N	283.07 W	15.52
1464.00	89 24	N 90 0 W	1184.66	292.55	21.94 N	292.07 W	11.60
1474.00	89 6	S 88 54 W	1184.79	302.54	21.84 N	302.07 W	11.40
1484.00	89 0	S 87 30 W	1184.95	312.52	21.53 N	312.06 W	14.03
1494.00	88 42	S 86 24 W	1185.15	322.49	21.00 N	322.04 W	11.40
1504.00	88 18	S 85 48 W	1185.42	332.44	20.32 N	332.02 W	7.21
1514.00	89 18	S 86 30 W	1185.62	342.39	19.65 N	341.99 W	12.20

GENERAL CHEMICAL CANADA L[illegible]
BRINE WELL #R-10 TO #R-5
ANDERDON TWP., ESSEX CO., MI

MEASURED DEPTH	INCL.	DIRECTION	VERTICAL DEPTH	VERTICAL SECTION	RECTANGULAR COORDINATES		DLS Deg/100'
1524.00	90 0	S 86 54 W	1185.69	352.36	19.07 N	351.98 W	8.06
1534.00	90 30	S 87 18 W	1185.64	362.33	18.57 N	361.96 W	6.40
1544.00	90 24	S 87 30 W	1185.56	372.30	18.11 N	371.95 W	2.24
1553.00	89 42	S 88 12 W	1185.56	381.28	17.77 N	380.95 W	11.00
1563.00	87 54	S 88 18 W	1185.76	391.26	17.47 N	390.94 W	18.03
1573.00	87 24	S 87 42 W	1186.17	401.24	17.12 N	400.92 W	7.81
1583.00	89 6	S 88 48 W	1186.48	411.22	16.82 N	410.91 W	20.24
1593.00	89 24	S 87 48 W	1186.61	421.20	16.52 N	420.91 W	10.44
1603.00	88 24	S 87 12 W	1186.80	431.17	16.08 N	430.90 W	11.66
1614.00	88 24	S 87 30 W	1187.11	442.14	15.57 N	441.88 W	2.73
1624.00	89 42	S 88 48 W	1187.28	452.12	15.25 N	451.87 W	18.38
1634.00	91 6	N 89 0 W	1187.21	462.11	15.23 N	461.87 W	26.07
1643.00	89 12	N 89 12 W	1187.18	471.11	15.38 N	470.87 W	21.23
1653.00	88 48	N 89 54 W	1187.36	481.11	15.45 N	480.87 W	8.06
1663.00	90 24	S 89 12 W	1187.43	491.10	15.39 N	490.87 W	18.36
1673.00	90 42	S 88 48 W	1187.33	501.09	15.22 N	500.87 W	5.00
1683.00	90 0	S 88 30 W	1187.27	511.08	14.98 N	510.86 W	7.61
1693.00	89 54	S 89 12 W	1187.28	521.07	14.78 N	520.86 W	7.07
1703.00	90 12	S 89 18 W	1187.27	531.06	14.65 N	530.86 W	3.16
1713.00	90 30	N 88 24 W	1187.21	541.06	14.73 N	540.86 W	23.19
1723.00	90 6	N 88 6 W	1187.16	551.06	15.03 N	550.86 W	5.00
1733.00	88 48	N 89 0 W	1187.25	561.06	15.29 N	560.85 W	15.81
1743.00	88 0	S 89 54 W	1187.53	571.05	15.37 N	570.85 W	13.60
1753.00	88 6	N 89 30 W	1187.87	581.04	15.40 N	580.84 W	6.08
1762.00	89 24	S 89 48 W	1188.07	590.04	15.42 N	589.84 W	16.40
1772.00	90 24	S 89 54 W	1188.09	600.03	15.40 N	599.84 W	10.05
1782.00	91 6	N 88 54 W	1187.95	610.03	15.49 N	609.84 W	13.89
1792.00	91 36	N 87 18 W	1187.72	620.03	15.82 N	619.83 W	16.76
1802.00	92 0	N 86 12 W	1187.40	630.02	16.38 N	629.81 W	11.70
1812.00	91 0	N 86 24 W	1187.14	640.01	17.03 N	639.78 W	10.20
1822.00	90 36	N 86 48 W	1187.00	650.00	17.62 N	649.76 W	5.66
1832.00	90 36	N 87 12 W	1186.90	660.00	18.15 N	659.75 W	4.00
1842.00	91 30	N 86 6 W	1186.72	669.99	18.73 N	669.73 W	14.21
1853.00	90 54	N 87 18 W	1186.49	680.98	19.36 N	680.71 W	12.19
1863.00	90 18	N 87 24 W	1186.38	690.98	19.82 N	690.70 W	6.08
1873.00	88 36	N 87 42 W	1186.48	700.98	20.25 N	700.69 W	17.26
1882.00	89 12	N 89 6 W	1186.65	709.98	20.50 N	709.68 W	16.92
1892.00	90 36	N 89 24 W	1186.67	719.98	20.63 N	719.68 W	14.32
1902.00	91 54	N 89 18 W	1186.45	729.97	20.75 N	729.68 W	13.04
1915.00	92 12	N 89 6 W	1185.98	742.96	20.93 N	742.67 W	2.77

GENERAL CHEMICAL CANADA L
BRINE WELL #R-10 TO #R-5
ANDERDON TWP., ESSEX CO., MI

MEASURED DEPTH	INCL.	DIRECTION	VERTICAL DEPTH	VERTICAL SECTION	RECTANGULAR COORDINATES		DLS Deg/100'
1925.00	92 24	N 88 48 W	1185.58	752.95	21.11 N	752.66 W	3.60
1935.00	91 42	N 88 36 W	1185.22	762.95	21.34 N	762.65 W	7.28
1945.00	90 18	S 89 48 W	1185.05	772.94	21.44 N	772.65 W	21.26
1955.00	90 36	S 89 24 W	1184.97	782.94	21.37 N	782.65 W	5.00
1976.00	92 30	N 88 0 W	1184.40	803.93	21.63 N	803.64 W	15.33
1986.00	92 12	N 87 18 W	1183.99	813.92	22.04 N	813.62 W	7.61
1996.00	91 54	N 87 24 W	1183.64	823.91	22.50 N	823.60 W	3.16
2008.00	91 12	N 87 42 W	1183.31	835.90	23.01 N	835.59 W	6.35
2018.00	91 12	N 87 30 W	1183.10	845.90	23.43 N	845.57 W	2.00
2029.00	90 6	N 87 48 W	1182.98	856.90	23.88 N	856.56 W	10.36
2041.00	89 0	N 87 6 W	1183.07	868.89	24.42 N	868.55 W	10.86
2050.00	89 12	N 87 12 W	1183.21	877.89	24.87 N	877.54 W	2.48
2060.00	89 24	N 87 0 W	1183.33	887.89	25.37 N	887.53 W	2.83
2072.00	89 18	N 87 30 W	1183.47	899.88	25.95 N	899.51 W	4.25
2082.00	89 42	N 88 6 W	1183.56	909.88	26.33 N	909.50 W	7.21
2092.00	90 42	S 89 36 W	1183.52	919.88	26.46 N	919.50 W	25.08
2107.00	91 0	N 88 24 W	1183.30	934.88	26.62 N	934.50 W	13.48
2122.00	92 0	N 84 12 W	1182.91	949.86	27.59 N	949.46 W	28.77
2134.00	92 0	N 84 12 W	1182.49	961.81	28.80 N	961.39 W	0
2149.00	92 0	N 84 12 W	1181.96	976.76	30.31 N	976.30 W	0

Final location: 976.77 feet at N 88 13 W
Plane of Vertical Section: 271.52 degrees

GREAT LAKES DIRECTIONAL DRILLING

Report of Survey

Minimum Curvature Method

MEASURED DEPTH	INCL.	DIRECTION	VERTICAL DEPTH	VERTICAL SECTION	RECTANGULAR COORDINATES		DLS Deg/100'
1925.00	92.40	271.20	1185.58	752.93	21.11 N	752.66 W	
1935.00	91.70	275.00	1185.22	762.92	21.65 N	762.64 W	38.61
1946.00	92.00	277.50	1184.87	773.88	22.85 N	773.57 W	22.88
1956.00	91.40	279.30	1184.57	783.82	24.31 N	783.45 W	18.97
1966.00	90.40	279.30	1184.41	793.74	25.92 N	793.32 W	10.00
1976.00	89.20	278.80	1184.45	803.66	27.50 N	803.20 W	13.00
1986.00	87.90	277.40	1184.70	813.60	28.90 N	813.09 W	19.10
1997.00	87.50	274.80	1185.14	824.57	30.07 N	824.02 W	23.89
2009.00	88.90	274.70	1185.52	836.55	31.07 N	835.97 W	11.70
2019.00	89.20	274.00	1185.68	846.54	31.82 N	845.94 W	7.61
2029.00	89.60	275.70	1185.79	856.53	32.67 N	855.91 W	17.46
2041.00	89.80	275.60	1185.85	868.50	33.85 N	867.85 W	1.86
2051.00	90.30	273.30	1185.84	878.49	34.63 N	877.82 W	23.54
2061.00	91.30	274.00	1185.70	888.49	35.26 N	887.79 W	12.21
2072.00	91.20	273.00	1185.46	899.48	35.93 N	898.77 W	9.13
2082.00	90.70	271.70	1185.30	909.48	36.34 N	908.76 W	13.93
2092.00	89.10	269.20	1185.32	919.47	36.42 N	918.76 W	29.68
2123.00	92.20	270.10	1184.96	950.44	36.23 N	949.75 W	10.41
2133.00	93.10	271.00	1184.50	960.43	36.33 N	959.74 W	12.72
2164.00	93.00	271.00	1182.85	991.38	36.87 N	990.69 W	.32

Final location: 991.38 feet at 272.13 degrees
Plane of Vertical Section: 272.07 degrees

GENERAL CHEMICAL
BRINE WELL R-10 TO R-5
ANDERDON TWP., ESSEX CO., ONTARIO

GREAT LAKES DIRECTIONAL DRILLING

Report of Survey

Minimum Curvature Method

MEASURED DEPTH	INCL.	DIRECTION	VERTICAL DEPTH	VERTICAL SECTION	RECTANGULAR COORDINATES		DLS Deg/100'
1966.00	90 24	N 80 42 W	1184.41	793.74	25.92 N	793.32 W	
1997.00	87 30	N 85 36 W	1184.98	824.61	29.62 N	824.08 W	18.36
2009.00	89 36	N 84 18 W	1185.28	836.59	30.67 N	836.03 W	20.58
2092.00	89 6	S 89 12 W	1186.22	919.54	34.22 N	918.90 W	7.85
2123.00	92 18	N 90 0 W	1185.85	950.50	34.00 N	949.90 W	10.64

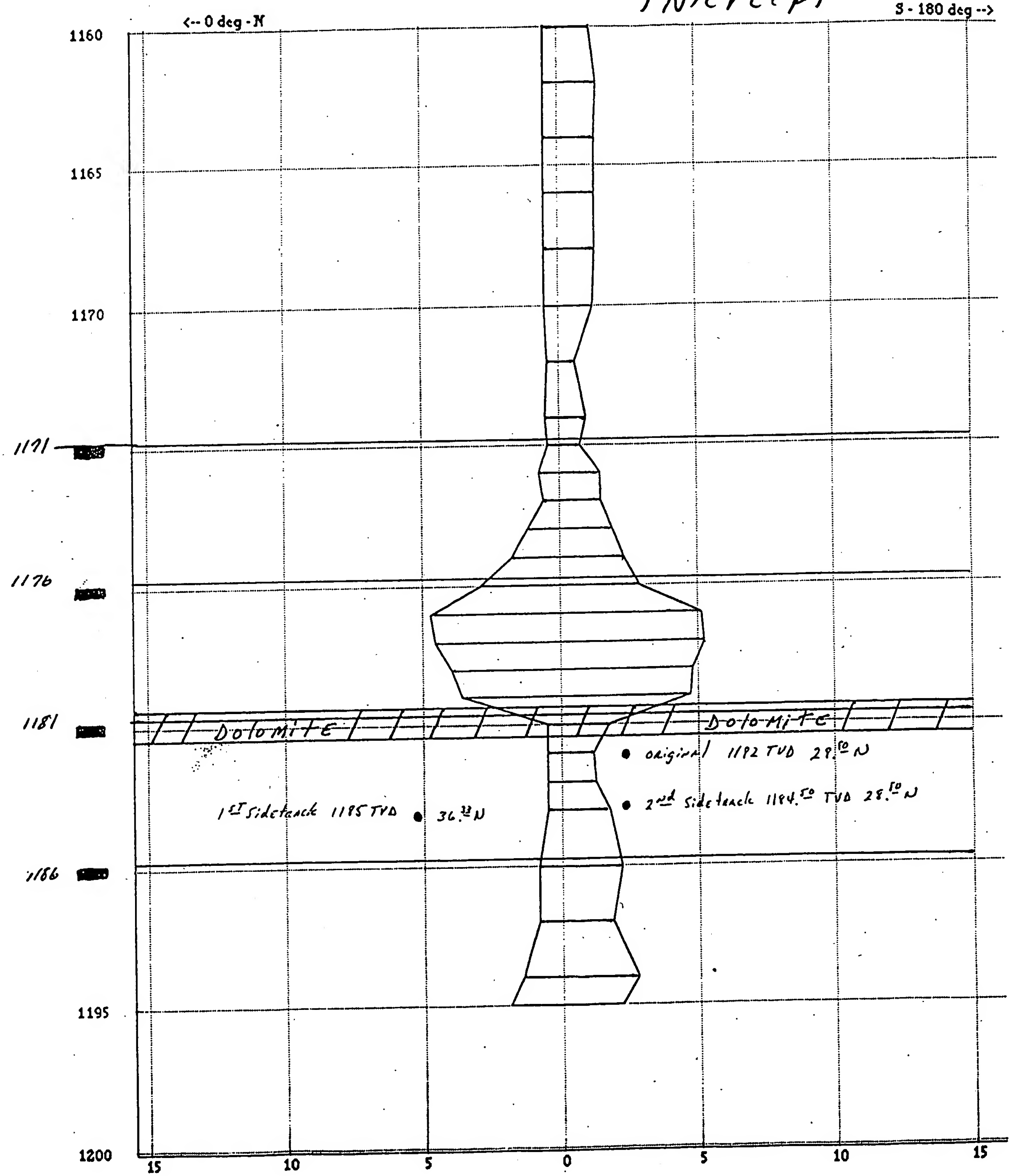
Final location: 950.50 feet at N 87 57 W
Plane of Vertical Section: 272.07 degrees

GENERAL CHEMICAL
AMHERSTBURG, ONT.

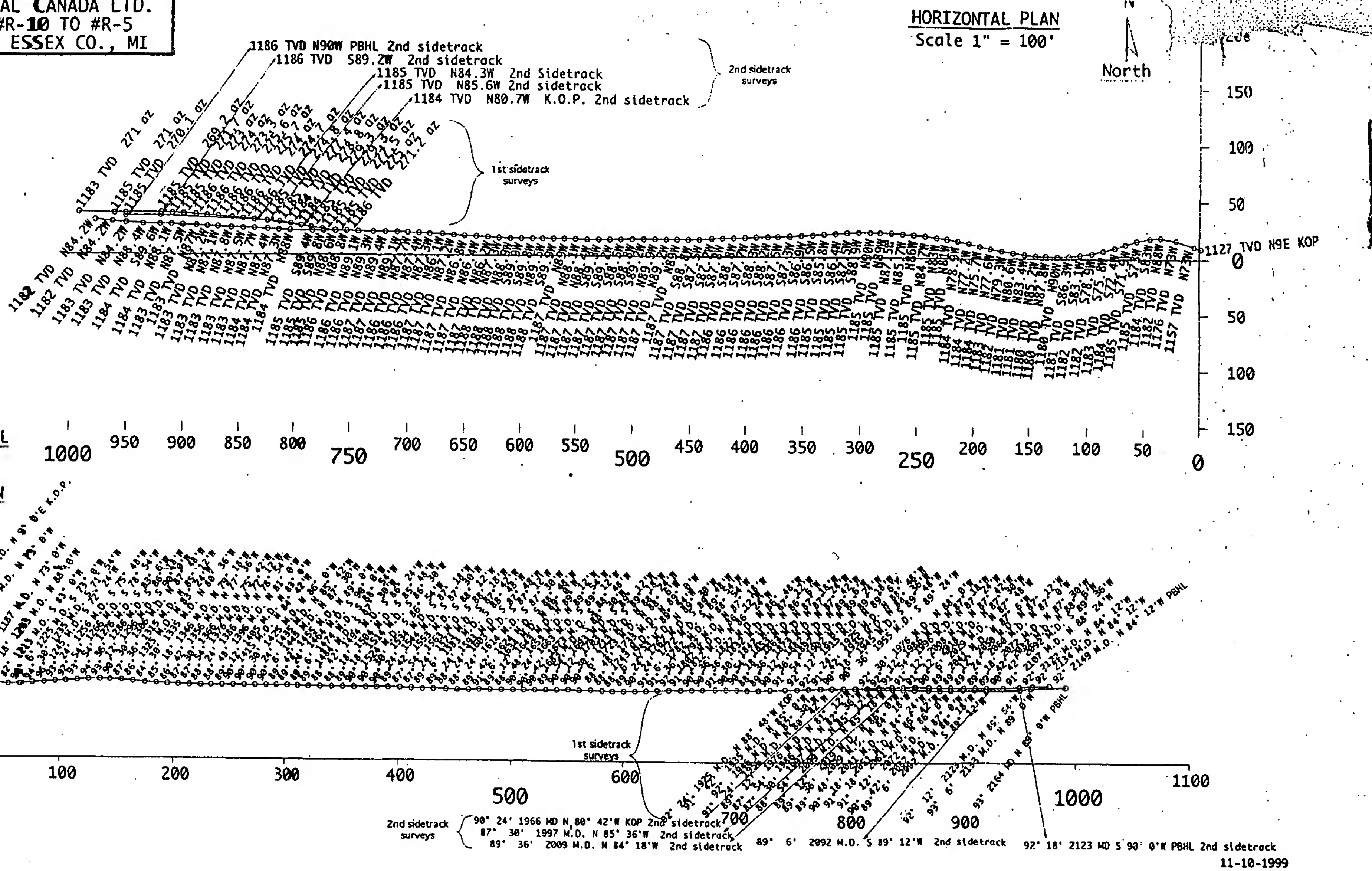
SONARWIRE, INC
Vertical Cross Section

BRINE WELL NO. R-5
R-5 Fri, Oct 29, 1999

Note enlarged cavity for intercept



ENERAL CHEMICAL CANADA LTD.
BRINE WELL #R-10 TO #R-5
ANDERDON TWP., ESSEX CO., MI



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